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Encouraging intermodality: A stated preference analysis of freight mode choice in Rio Grande do Sul

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ABSTRACT

Brazil's freight modal split is mainly focused on road transport. The imbalance between different transport modes suggests a need to promote alternative modalities to strengthen the competitiveness and provide a more sustainable economic development. The goal of this paper is to identify logistics managers' preferences for freight transport service attributes for the case of Rio Grande do Sul in Brazil, and discuss which transport policies could encourage multimodality and more sustainable uses of available transport infrastructure. In this paper we used the stated preference (SP) technique for collecting data on respondents' choices among hypothetical options. The experimental design was structured using an Efficient design. Discrete choice models were used to identify the preferences of respondents and discuss some possible sustainable policies that could increase the competitiveness of the region. The model structures studied were: multinomial logit; mixed logit as a special case of random coefficients; mixed logit error components- considering panel effect and mixed logit error components – including possible correlations between attributes of intermodal alternatives. Parameters estimated from the models were used to compute subjective value of time savings, which was Euro/t.h 0.34 (R$/t. h 1.088) for the selected model. The direct and cross elasticity values of the probability of choosing a transport mode for the different attributes studied show that the shippers significantly value the fulfilment of delivery time and cost, suggesting that those attributes are the most important ones in the choice of transport mode in this State of Brazil. Simulation results suggest investments for increasing the reliability of intermodal alternatives are more effective to encourage intermodality than cost reductions. Policies and investments to encourage multimodality should prioritize the increase of intermodal alternatives reliability and combined policies of cost reduction and reliability.

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1. Introduction

Brazil's freight modal split is mainly focused on road transport. In the state of Rio Grande do Sul, one of the most populous states of Brazil, 85.3% of the total cargo is transported by road. This value is above the Brazilian mean of 68.6% transported by road (Secretaria da Coordenação e Planejamento, 2015). The imbalance between different transport modes suggests a need to promote alternative modalities to strengthen the competitiveness and provide a more sustainable economic development.

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Planning for a more efficient and sustainable transport system within the state is being carried out through studies that seek to promote the rationalization of transport flows among different modes, encouraging multimodality. The final aim is to increase competitiveness in logistics of Rio Grande do Sul that allows better access to domestic and international markets.

Increasing the efficiency of transport systems to improve the competitiveness of a region needs the formulation of appropriate transport policies. To formulate adequate transport policies is essential to know supply chain actors' preferences about different attributes of available transport modalities. In this regard, assessing firms' value of service for freight transport in different modes is important for policy makers, public agencies, local governments and researchers (Danielis and Marcucci, 2007). The goal of this paper is to identify logistics managers' preferences for freight transport service attributes for the case of Rio Grande do Sul in Brazil, and discuss which transport policies could encourage multimodality and more sustainable uses of available transport infrastructure. In this paper, stated preference (SP) technique for collecting data on respondents' choices among hypothetical options is described and standard econometric discrete choice models are estimated to identify the preferences and discuss some possible sustainable policies that could increase the competitiveness of the region.

The rest of this paper is organized as follows. Section 2 describes the methodology adopted for models' formulation; Section 3 discusses the data collected, and Section 4 presents the estimation results. The paper ends with conclusions and suggestions for future research.

2. Modelling approach

Discrete choice models were estimated to determine the effect of freight service attributes on the logistics managers' preferences. Most of the discrete choice models used for travel behaviour applications are based on utility theory (McFadden, 1974), which assumes that the decision-maker's preference for an alternative can be reduced to a scalar utility value. Then, the decision-maker selects the alternative in the choice set with the highest utility value.

Several discrete choice model structures were tested, seeking better fit of the model regarding the data collected. The model structures studied were: (i) multinomial logit; (ii) mixed logit as a special case of random coefficients (ML-RC model); (iii) mixed logit error components- considering panel effect (ML-EC model); and (iv) mixed logit error components – including possible correlations between attributes of the intermodal alternatives (ML-EC2 model). Models' estimation was performed using the software Biogeme (Bierlaire, 2003).

Initially simpler structures were tested (i.e. MNL models). The multinomial logit (MNL) (McFadden, 1974) is one of the simplest discrete choice models and also the most used. It is based on the assumption that the random term ε_{iq} of the utility function is identically and independently distributed according to a Gumbel distribution (Extreme Value Type I). This assumption for the distribution of residuals is rather simplistic, once they depend on the hypothesis of independence and homoscedasticity of the residues (Ben-Akiva et al., 2003). The MNL yield to the following probability model (Eq. (1)):

$$P_{iq} = \frac{e^{\lambda V_{iq}}}{\sum_{\forall j \epsilon A(q)} e^{\lambda V_{iq}}} \tag{1}$$

where λ is a parameter related to the common standard deviation of the Gumbel distribution. In practise, it cannot be estimated separately from parameters, and is usually normalized to 1. The MNL considers that estimated parameters associated to various variables included in the utility function specification are the same for all individuals. In addition, its model structure restricts the substitution patterns among alternatives and does not allow for correlations due to unobserved factors. To overcome limitations of the MNL model, more flexible model structures has been adopted.

The Mixed Logit (ML) model is a highly flexible model that can approximate any random utility model (McFadden and Train, 2000). Mixed logit models can be derived under a variety of different behavioural specifications. The model is defined on the basis of the functional form for its choice probabilities (Train, 2009). Mixed logit probabilities can be expressed as an integral of standard logit probabilities over a distribution of the parameters (Eq. (2)):

$$P_{iq} = \int L_{iq}(\theta) f(\theta) d(\theta) \tag{2}$$

where $L_{iq}(\theta)$ is typically an MNL probability evaluated at a set of parameters θ and their density function, $f(\theta)$, is known as 'mixing distribution' (Ortúzar and Willumsen, 2011). The ML model has two basic forms: *random coefficients* (RC) and *error components* (EC). The first version of the ML model considers a random coefficients structure, in which the marginal utility parameters are different for each sampled individual q, but do not vary across choice situations. The second one considers that the utility function contains at least two error terms. One error term allows the MNL probability to be obtained (and as such has the usual IID Extreme Value Type I distribution), while the other has a distribution freely chosen by the modeller, depending on the phenomenon he needs to reproduce (Ortúzar and Willumsen, 2011).

Taste variations have been represented in models by assuming that preferences are randomly distributed in the population. Thus, mixed logit models using random coefficient approach (ML-RC) were estimated, considering normal distribution for the *Total transport time* coefficient.

A possible correlation between the responses from the same respondent can also be included when estimating mixed logit but using the error component approach (ML-EC). The specification of these models is easily generalized to allow for

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